MARS CRATER INTERIOR LAYERS VIEWED BY HIRISE. P. S. Russell[1], C. Weitz[2], A. Lefort[1], N. Thomas[1], A. McEwen[3], and The HiRISE Team. [1]Physikalisches Institut, Univ. Bern, Bern, Switzerland, [2]Planetary Science Institute, Tucson, USA, [3]Lunar and Planetary Lab, Univ. Arizona, Tucson, USA. patrick.russell@space.unibe.ch

Introduction: On Earth, layering in sediments and rocks are important as records of biological, geochemical, atmospheric, and geologic activity through time. Several settings of layers have been discovered on Mars, including polar caps, canyon and valley walls, canyon interiors, crater interiors, chaos terrain, and intercrater plains (see [1] for a summary of HiRISE results thus far). We focus on layers in crater interiors in non polar regions, particularly in western and southern Arabia Terra, and compare them to layers in mid to high latitudes where the variable stability of ice over obliquity cycles [2] has the potential to produce interesting differences. Discovery of these crater interior layers in images from MOC [3] provides perhaps the strongest evidence (see e.g., [4] for pre-MGS evidence) that crater interiors are among the settings on Mars with the highest potential for the former existence of standing water. Profound implications of a standing water environment include a climate drastically different than todays and the possibility of martian life.

HiRISE high-resolution images (0.3-1.2 m/pxl), stereo anaglyphs, and 3-band color data provide an exciting new perspective of Mars, in which landscapes and processes revealed from orbit can begin to be related to the human scale. We will use the advanced imaging capabilities of HiRISE [5] to address the questions raised and left outstanding by the MOC analysis.

Arabia Craters: The layers of interest are regular, generally flat, often thin, composed of indurated material, and present in enclosed depressions, characteristics which favor deposition in a lacustrine environment, with episodic repetition, followed by diagenesis [3]. This suggests the local environment was once more Earth-like a [3]. Alternatively, layers were deposited subaerially, possibly in early Mars history when the atmosphere was thicker and rates of generation of fine-grained material due to impact and volcanism were higher [3]. Accumulation of the deposits throughout martian history as direct products of Tharsis volcanism is another possibility [6]. HiRISE high resolution (down to ~ 25 cm per pixel), color, and stereo capabilities are extremely well suited to further constrain the formation of these tantalizing deposits [1,5]. For example, large scale cross-bedding, which would identify an eolian dune environment, was not found in MOC analysis [3]. If this could be found at higher resolution, the conclusion that standing water is not required for deposition would be significant. The traceability of individual beds across an outcrop speaks to lateral continuity in depositional conditions. Stereo images allow qualitative and quantitative assessment of how flat-lying and horizontal the layers are. Emplacement of flat, horizontal, continuous layers is especially characteristic of environments involving still water.

Preliminary observations have identified non-conformable bedding in Becquerel crater (see figure in [1]) and potential cross-beds in another Arabia crater. HiRISE has already demonstrated how effective stereo viewing can be in interpreting layers that have experienced differential erosion [7]. Layering in Becquerel appears remarkably uniform in composition from color data, although a finer-grained darker material collects along scarps and in low areas (Fig. 1). Fractures are prevalent and lead to increased mass-wasting rates along layer edges. Blocky debris is scattered at the foot of scarps, but most surfaces are remarkably free of blocky debris, indicating that the material may be friable and easily eroded by the wind. Fallen blocks may experience more efficient removal than intact layers due to their higher surface area.

Eventually, although complicated, similar regional stratigraphic comparison amongst crater-interior layer sequences at high resolution may link emplacement of all crater interior layers in the region to a common time and/or process, or indicate that layer sequences within each crater resulted from variable processes and/or at different times.

Spallanzani Crater: Spallanzani Crater is located at high southern latitude, just south of Hellas Basin in a region under investigation for potential ground ice sublimation [8]. It is far enough north, however, that it does not contain mound deposits with morphology similar to those in some circum-polar craters suspected of being remnants of a formerly more extensive cap [9]. Initial observations suggest that interior layered deposits and associated processes are quite distinct from either circum-polar or equatorial Arabia craters.

The material that has collected within Spallanzani Crater since the impact and is now eroding has produced a pronounced stair-step pattern, exemplified in Fig 2. Layers appear as a sequence of broad plateaus which drop off abruptly down a steep slope to the next relatively flat area, and so on. This pronounced stair-step pattern suggests discreet boundaries between layers of different composition, or time of deposition, or both. The surface texture of the flat areas is similar in most places, characterized by a uniform tone, ripples that may be small dunes, thin furrows, and faint polygons. Dark spots are concentrated more in some areas and less in others.

Near the edge of the plateaus polygonal fracturing pattern becomes more pronounced. Highlighted along plateau edges by catching the sun, polygonal plates of surface material are tilted, with the higher end towards the plateau and the lower end being dropped down the slope. The slopes appear to be made up of mass-wasting debris falling from the plateau edge. The debris is comprised of unresolved material in some areas, but in others it includes plates or blocks that have slid part way down from the edge without breaking up. This suggests that plateau surfaces are more coherent, or stronger, than the underlying material making up the bulk of the thickness of a single "layer". It may be that while this crust protects the underlying material on plateau surfaces, the underlying material is being removed, possibly by eolian processes, from the side slope where it is not protected. This process results in the observed landscape (Fig. 2) as the underlying material erodes backwards into the plateau and the resistant surface is undercut, breaks into plates along polygonal fractures, and is dropped down, eventually also eroding. The material itself may be loosely held together sediment covered by a more cemented surface layer, or it may be ice-rich material protected from sublimation from above by a more dust-rich layer. Because of highlighting of the plateau edge and the variable concentration of black spots it is difficult to be sure just how flat-lying these surfaces and layers are. Stereo imaging by HiRISE will help determine their configuration.

Whereas the little observed variation in layer tone or texture might suggest it is breaks in time, not composition, that distinguishes layers, the identification of two distinct parts to each layer suggests it is composition that results in the layering after all. Either alternating deposition of variably friable materials or constant deposition of one friable material with cyclic variation in water abundance incorporated into the deposits could explain the observations.

A similar mass-wasting pattern of polygonally fractured, competent material has also recently been observed in ice-rich north polar layers [7]. Similarity with the polar deposits underscores the potential role of ice in governing landscape evolution well away from the poles, as well as the increased preservation potential afforded to ice by relatively thin lag deposits. Close comparison of polar, Spallanzani, and Arabia layers will determine if this close analogy is warranted or if some other material is leading to similar morphology and erosional style.

References: [1] Weitz C. et al. (2007) LPSC XXXVIII. [2] Head J. W. et al. (2003) Science, 426, 797-802. [3] Malin M. and Edgett K. (2000) Science, 290, 1927-1937. [4] Cabrol N. and Grin E. (1999) Icarus, 142, 160-172. [5] McEwen A. et a. (2007) J. Geophys. Res., 111, in press. [6] Hynek B. et al. (2003) J. Geophys. Res., 108 (E9), 5111. [7] Russell P. et al. (2007) LPSC XXXVIII. [8] Lefort A. et al. (2007) LPSC XXXVIII. [9] Russell P. and Head J. W.(2005) LPSC XXXV, #1541.

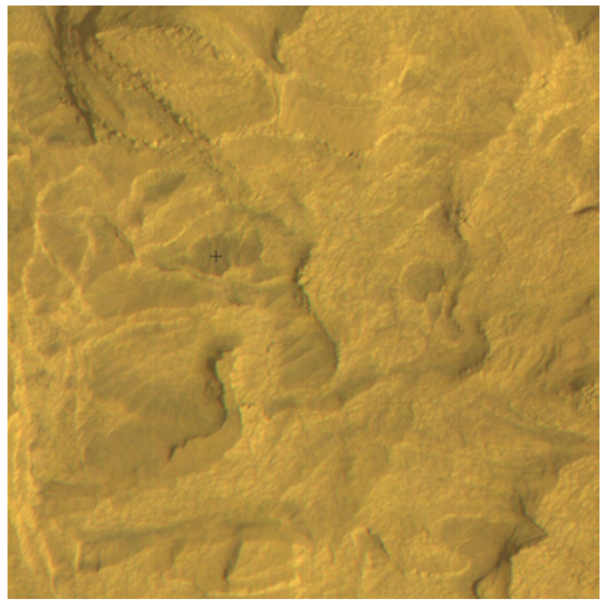

Figure 1: Color image of Becquerel crater interior layers. NIR channel in R, RED channel in G, BG channel in B. TRA_873_2015. ~300 m across.

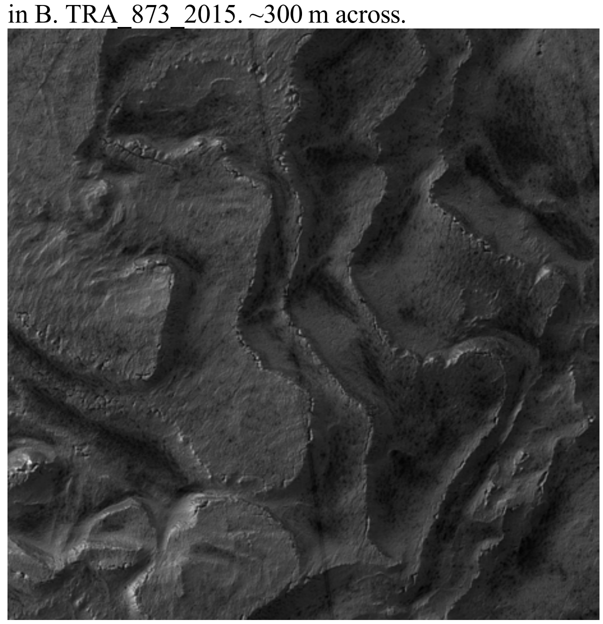

Figure 2. Spallanzani Crater interior layering and plateau erosion. PSP_001345_1215. ~1200 m across.